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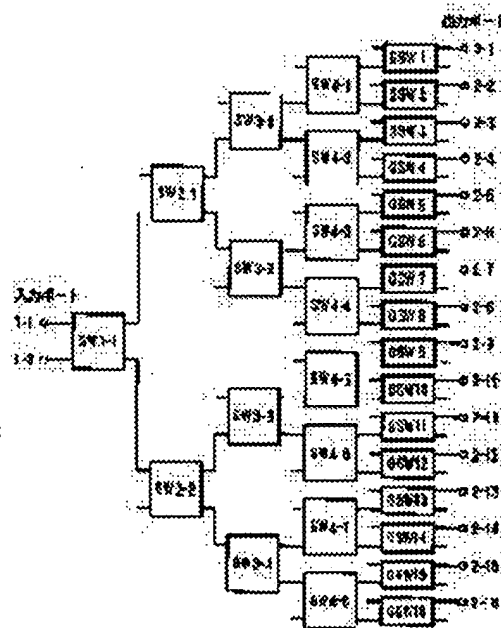
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(54) OPTICAL SPATIAL SWITCH

(57)Abstract:

PURPOSE: To reduce the crosstalk of the whole switch with small power consumption by utilizing characteristics of an asymmetrical MZI switch which has small crosstalk in a driving power OFF state with respect to an optical spatial switch used for an optical signal processing or optical communication system.

CONSTITUTION: In this optical spatial switch which has 2×2 thermo-optical effect optical switches arrayed and performs switching operation according to driving electric power supplied from a driving device to the heaters of the respective thermo-optical effect optical switches, thermo-optical effect optical switches (asymmetrical MZI switch) of asymmetrical Mach-Zehnder interferometer constitution are connected to the output ports of the thermal-optical effect optical switches of the final stage and a cross port where input light is outputted when the driving electric power is supplied is set as an output port.



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CLAIMS

[Claim(s)]

[Claim 1] The optical space switch characterized by setting up the cross port where input light is outputted when two or more thermooptic effect optical switches of 2x2 are arranged, the thermooptic effect optical switch of an unsymmetrical Mach-Zehnder-interferometer configuration is connected to the output port of each thermooptic effect optical switch of the last stage in the optical space switch switched according to the actuation power supplied to the heat heater of each thermooptic effect optical switch from a driving gear, respectively and actuation power is supplied as an output port.

[Claim 2] A driving gear is an optical space switch characterized by having a reference voltage generating means to generate the reference voltage corresponding [on the optical space switch according to claim 1 and] to the actuation power of each thermooptic effect optical switch, and the current regulator circuit which passes constant current at a heat heater according to said reference voltage.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the optical space switch used for optical signal processing or an optical transmission system.

[0002]

[Description of the Prior Art] The thing using the thermo-optic effect in quartz system optical waveguide is in one of the conventional optical space switches. This is arranged in the shape of a matrix on a quartz substrate by making a 2x2 thermo-optic-effect optical switch into a unit switch, and constitutes the optical space switch of NxM. This thermo-optic effect optical switch has the configuration (henceforth a "symmetry MZI switch") which used the symmetry Mach-Zehnder interferometer, and a configuration (henceforth an "unsymmetrical MZI switch") using an unsymmetrical Mach-Zehnder interferometer. The example which constituted the 8x8 light space switch using this unsymmetrical MZI switch is shown in the paper (20 93 R. Nagase, et al., and "Silica-Based 8*8 Optical-Matrix Switch Module with Hybrid Integrated Driving Circuits", ECOC' MoPl. 2, pp.17- 1993).

[0003] Drawing 5 shows the basic configuration and switching characteristic of a symmetry MZI switch. A symmetry MZI switch is constituted in drawing by input port 41a and 41b, output ports 42a and 42b, two 3dB couplers 43 and 44, two optical waveguides 45a and 45b formed between them, and the heat heater 46 vapor-deposited on optical waveguide. In addition, the waveguide length of optical waveguides 45a and 45b is equal. Switching which outputs the input signal light of input port 41a (41b) to output port 42a or output port 42b is performed by passing a current at the heat heater 46, changing the refractive index of optical waveguide to it thermally, and changing waveguide length to it equivalent.

[0004] The switching characteristic of a symmetry MZI switch is drawing 5 (b). It has periodicity to the actuation power supplied to the heat heater 46 so that it may be shown. A continuous line shows the output to a through port (it is output port 42a to input port 41a), and a broken line shows the output to a cross port (it is output port 42b to input port 41a). That is, the input signal light of input port 41a is outputted to output port 42b used as a cross port, when [off] not supplying power to the heat heater 46, and it is outputted to output port 42a which becomes a through port at the time of the ON which supplies power.

[0005] Drawing 6 shows the basic configuration and switching characteristic of an unsymmetrical MZI switch. In drawing, although an unsymmetrical MZI switch is the same configuration as a symmetry MZI switch, the waveguide length of two optical waveguides 45a and 45b differs by the half-wave length ($\lambda/2$).

[0006] The switching characteristic of an unsymmetrical MZI switch is drawing 6 (b). It becomes the case of a symmetry MZI switch, and reverse so that it may be shown. That is, the input signal light of input port 41a is outputted to output port 42a used as a through port (continuous line), when [off] not supplying power to the heat heater 46, and it is outputted to output port 42b which becomes a cross port (broken line) at the time of the ON which supplies power.

[0007] In addition, when signal light is outputted to a through port with a symmetry MZI switch and an unsymmetrical MZI switch, the cross talk to a cross port is small. On the contrary, when signal light is outputted to a cross port, the cross talk to a through port is large. This is because it is difficult to produce so that the binding fraction of two 3dB couplers 43 and 44 may become equal. Moreover, when a cross talk does not become the minimum value for a fabrication error, a cross talk can be made into min if predetermined offset power is supplied.

[0008] By the way, generally the optical transmission system requires about -30dB as a cross talk in the optical whole space switch. However, although the thermo-optic effect optical switch mentioned above can do a cross talk in -20dB or less, it is set to about -15dB by accumulation of a cross talk with the optical whole space switch. That is, even if it tuned offset power finely in each thermo-optic effect optical switch and made the cross talk into min, it was not easy to set the cross talk of the optical whole space switch to -30dB or less.

[0009] Drawing 7 shows the configuration of the conventional thermo-optic effect optical switch driving gear. In drawing, the heat heater 46 is a configuration with which supply of power is controlled by turning on and off of the actuation transistor 51 of a current regulator circuit. The laser trimming resistance 52 connected to juxtaposition at this actuation transistor 51 is the resistor by which resistance was finely tuned by the laser beam, and is for supplying offset power. That is, when the actuation transistor 51 is OFF, offset power is supplied by impressing the electrical potential difference proportional to the division ratio of heat heater resistance and laser trimming resistance to the heat heater 46, and passing a corresponding current. In addition, when the actuation transistor 51 is ON, a current does not flow for the laser trimming resistance 52.

[0010]

[Problem(s) to be Solved by the Invention] By the way, the thermo-optic effect optical switch which constitutes an optical space switch has more than one, and not each offset power is necessarily the same. Moreover, there is variation also in the heat heater resistance of each thermo-optic effect optical switch. Therefore, each thermo-optic effect optical switch driving gear needed to measure the optimum value and heat heater resistance of offset power of the thermo-optic effect optical switch which corresponds, respectively, and needed to adjust laser trimming resistance according to the optimum value and heat heater resistance of offset power which were acquired. Therefore, fabrication effectiveness was bad and there was a place which lacks in versatility.

[0011] That is, it was difficult to realize easily the small cross talk property which is less than -30dB with the configuration which uses laser trimming resistance and performs offset power control for reduction of a cross talk.

[0012] Moreover, since the current flowed [the thermo-optic effect optical switch] to laser trimming resistance also by the OFF state, there was a problem to which the power consumption of the optical whole space switch becomes large. This invention aims at offering the optical space switch which can reduce the cross talk of the whole switch with small power consumption taking advantage of the property of an unsymmetrical MZI switch with a small cross talk at the time of actuation power OFF.

[0013]

[Means for Solving the Problem] This invention arranges two or more thermo-optic effect optical switches of 2x2, and in the optical space switch switched according to the actuation power supplied to the heat heater of each thermo-optic effect optical switch from a driving gear, when the thermo-optic effect optical switch (unsymmetrical MZI switch) of an unsymmetrical Mach-Zehnder-interferometer configuration is connected to the output port of each thermo-optic effect optical switch of the last stage, respectively and actuation power is supplied to it, it sets up the cross port where input light is outputted as an output port.

[0014] Moreover, a driving gear is equipped with a reference voltage generating means to generate the reference voltage according to the actuation power of each thermo-optic effect optical switch, and the current regulator circuit which passes constant current at a heat heater according to reference voltage.

[0015]

[Function] In the optical space switch of this invention, an unsymmetrical MZI switch is arranged as a

gate switch to each output port. And the unsymmetrical MZI switch corresponding to the output port of signal light is set to ON, and others are made off. An unsymmetrical MZI switch has a good operating characteristic by the side of a cross port, when off, and when predetermined offset power is supplied. Therefore, even if the cross talk produced with each thermo-optic effect optical switch which constitutes an optical space switch accumulates, a cross talk can be substantially made small by making off unsymmetrical MZI switches other than an output port.

[0016] In addition, since generating of a cross talk is permitted in each thermo-optic effect optical switch, supply of the offset power for reducing a cross talk to them is unnecessary. That is, since the thing whose supply of offset power is the need is only an unsymmetrical MZI switch used as a gate switch, power consumption can be reduced while being able to simplify a driving gear.

[0017] Moreover, the laser trimming resistance for supplying offset power becomes unnecessary by setting up the reference voltage according to the actuation power and offset power of a thermo-optic effect optical switch, and using the driving gear of a configuration of passing the constant current proportional to the reference voltage for a heat heater.

[0018]

[Example] Drawing 1 shows the example configuration of the optical space switch of this invention. Here, the switch configuration of 2x16 is shown.

[0019] In drawing, it arranges on two symmetry MZI switch SW2-1-SW 2-2 and the 3rd stage to four symmetry MZI switch SW3-1-SW(s) 3-4, and eight symmetry MZI switch SW4-1-SW(s) 4-8 are arranged in the shape of a tree on the 4th stage on the 1st stage at one symmetry MZI switch SW 1-1 and the 2nd stage. The input port of the symmetry MZI switch SW 1-1 of the 1st stage is set to the input port 1-1 of an optical space switch, and 1-2. 16 unsymmetrical MZI switches GSW1-GSW16 are connected to each eight output port of symmetry MZI switch SW4-1-SW 4-8 of the 4th stage as a gate switch. each unsymmetrical MZI switches GSW1-GSW16 -- the preceding paragraph -- each -- let the output port used as a cross port be the output port 2-1 to 2-16 of an optical space switch to the input port connected to symmetry MZI switch SW4-1-SW 4-8.

[0020] The signal light inputted from input port 1-1 or input port 1-2 is switched to the unsymmetrical MZI switch corresponding to either of 16 output ports 2-1 to 2-16 by such configuration according to the on-off condition of symmetry MZI switch SW1-1-SW 4-8 of each stage. Only this unsymmetrical MZI switch is set to ON, and other unsymmetrical MZI switches are made off.

[0021] Here, the case where the signal light inputted from input port 1-1 is switched to an output port 2-1 is explained. The signal light inputted from input port 1-1 is switched to the unsymmetrical MZI switch GSW1 corresponding to an output port 4-1 by setting only the symmetry MZI switch SW 1-1 of the 1st stage to ON, and making other symmetry MZI switches off. By setting this unsymmetrical MZI switch GSW1 to ON, signal light can be taken out to an output port 2-1.

[0022] By the way, by the symmetry MZI switch, it is [about] to a through port side at the time of an OFF state. -A 10dB cross talk arises. Therefore, in the unsymmetrical MZI switch GSW2 corresponding to an output port 2-2, it is [about] from the symmetry MZI switch SW 4-1. -A 10dB cross talk signal will be inputted. Then, the unsymmetrical MZI switch GSW2 is made off. Since the cross talk which produces an unsymmetrical MZI switch in a cross port side at the time of an OFF state is -20dB or less, the cross talk signal outputted to an output port 2-2 can be done in -30dB or less together with the cross talk property of the symmetry MZI switch SW 4-1. In addition, when the operating characteristic in the OFF state of an unsymmetrical MZI switch exceeds -20dB, the cross talk signal outputted to an output port 2-2 is set to -30dB or less by supplying predetermined offset power.

[0023] Moreover, the cross talk signal from the symmetry MZI switch SW 3-1 is inputted into an output port 2-3 and the unsymmetrical MZI switches GSW3 and GSW4 corresponding to 2-4. Since this cross talk signal passes the symmetry MZI switch SW 4-2 of an OFF state, the cross talk signal inputted into the unsymmetrical MZI switches GSW3 and GSW4 is set to -10dB or less (3 - 20dB or less of GSW(s)). Therefore, an output port 2-3 and the cross talk signal outputted to 2-4 can be done in -30dB or less by making them off. In addition, on the unsymmetrical MZI switch GSW3, supply of offset power is unnecessary.

[0024] Moreover, the cross talk signal from the symmetry MZI switch SW 2-1 is inputted into the unsymmetrical MZI switches GSW5-GSW8 corresponding to an output port 2-5 to 2-8. Since this cross talk signal passes the symmetry MZI switch SW 3-2 of an OFF state, SW 4-3, and SW 4-4, the cross talk signal inputted into the unsymmetrical MZI switches GSW5-GSW8 is set to -10dB or less (GSW5-7 - 20dB or less of GSW(s)). Therefore, the cross talk signal outputted to an output port 2-5 to 2-8 can be done in -30dB or less by making them off. In addition, on the unsymmetrical MZI switches GSW5-GSW7, supply of offset power is unnecessary.

[0025] On the other hand, the cross talk signal from the symmetry MZI switch SW 1-1 is inputted into the unsymmetrical MZI switches GSW9-GSW16 corresponding to an output port 2-9 to 2-16. With a symmetry MZI switch, the cross talk produced in a cross port side at the time of an ON state is -20dB or less. Therefore, the cross talk signal inputted into the unsymmetrical MZI switches GSW9-GSW16 is set to -20dB or less, and can do the cross talk signal outputted to an output port 2-9 to 2-16 in -30dB or less by making them off. In addition, supply of offset power is unnecessary.

[0026] Thus, the cross talk signal inputted into the unsymmetrical MZI switches GSW2-GSW16 when taking out the signal light inputted from input port 1-1 to an output port 2-1 is [about] at the maximum. -It is set to 10dB and the cross talk signal of an output port 2-2 to 2-16 can be set to -30dB or less by making them off.

[0027] Since especially the cross talk produced with the symmetry MZI switch used as ON is -20dB or less, with the unsymmetrical MZI switch which the cross talk signal reaches, a cross talk can be set to -30dB or less only by being off. For example, in taking out the signal light inputted from input port 1-1 to an output port 2-6, the symmetry MZI switch SW 1-1, SW 2-1, SW 3-2, and SW 4-3 are set to ON, and it sets the unsymmetrical MZI switch GSW6 to ON. Since the cross talk signal inputted in addition to unsymmetrical MZI switch GSW6 is -20dB or less at this time, a cross talk can be done in -30dB or less only by making them off.

[0028] Drawing 2 shows the example configuration of the driving gear of an unsymmetrical MZI switch. actuation current I_0 which 46 is a heat heater and is controlled by the current regulator circuit 11 in drawing It flows. Constant power control in which this current regulator circuit 11 is not influenced by a control circuit 12, memory 13, D/A converter 14, an adder 15, and the electrical-potential-difference current conversion circuit 16 at the resistance and others of the heat heater 46 is performed.

[0029] A control circuit 12 makes memory 13 memorize the switching power value and offset power value of the heat heater 46 beforehand. If the control instruction SW (on) to which a control circuit 12 makes an unsymmetrical MZI switch an ON state is issued, the switching power value and offset power value which correspond from memory 13 will be inputted into D/A converter 14, and will be changed into an analog voltage value (V_{sw} and V_{off}), respectively, and it will be added with an adder 15, and will be inputted into the electrical-potential-difference current conversion circuit 16. Moreover, control instruction SW (off) to which a control circuit 12 makes an unsymmetrical MZI switch an OFF state If it takes out, the offset power value which corresponds from memory 13 will be inputted into D/A converter 14, and will be changed into an analog voltage value (V_{off}), and it will be inputted into the electrical-potential-difference current conversion circuit 16 through an adder 15. That is, in the electrical-potential-difference current conversion circuit 16, it is reference voltage V_{ref} . It carries out and is $V_{sw} + V_{off}$. Or V_{off} It is the current I_{ref} to which it was given and a current regulator circuit 11 is proportional to it. It passes. In addition, direct continuation of the heat heater 46 is carried out to the electrical-potential-difference current conversion circuit 16, and it is reference voltage V_{ref} . Embraced current I_{ref} It is also possible to make it pass. Thus, since the optimal current for the heat heater 46 can be passed to compensate for ON/OFF of an unsymmetrical MZI switch, it becomes unnecessary trimming resisting for supplying offset power, and the fine adjustment can also be performed easily.

[0030] Here, the configuration which expressed concretely the current regulator circuit 11 and the electrical-potential-difference current conversion circuit 16 is shown in drawing 3. a part for a voltage drop ($V = R \cdot I_0$) and reference voltage V_{ref} according [the differential amplifier 21] to the heat heater (resistance R) 46 comparing -- difference -- an electrical potential difference is outputted. the actuation transistor 22 -- this difference -- an electrical potential difference -- responding -- operating -- reference

voltage V_{ref} Embraced actuation current I_0 It passes. Thereby, constant power actuation which compensated the variation in resistance of the heat heater 46 is performed.

[0031] In addition, since it is not necessary to supply offset power to a symmetry MZI switch, it is not necessary to make memory 13 memorize an offset power value and, and an adder 15 becomes unnecessary in the driving gear.

[0032] Drawing 4 shows the example of a configuration of the driving gear corresponding to the optical space switch of the example of drawing 1. In drawing, it is at most one that a symmetry MZI switch is turned on on each stage. Therefore, it has 1 set of D/A converters 14, and a current regulator circuit (here, the electrical-potential-difference current conversion circuit 16 shall be included) 11 for every stage, and changes and connects through the heat heater 46 and analog switch of each symmetry MZI switch. The analog switches 31 corresponding to the 2nd stage are 1x2 configurations, the analog switches 31 corresponding to the 3rd stage are 1x4 configurations, and the analog switches 31 corresponding to the 4th stage are 1x8 configurations. By such configuration, circuit magnitude can be substantially made small.

[0033] Moreover, the unsymmetrical MZI switches GSW1-GSW16 set one piece to ON, and presuppose that others are off 15 pieces. Therefore, it can respond with 1 set of D/A converters 14, an adder 15, a current regulator circuit 11, and the analog switch of 1x16 configurations.

[0034] However, when off, offset power may need to be supplied because of cutoff of a cross talk. In the example mentioned above, since an about -10dB cross talk signal is inputted into the unsymmetrical MZI switch GSW2 corresponding to an output port 2-2 when switching the signal light of input port 1-1 to an output port 2-1, supply of offset power may be needed. On the other hand, since the cross talk inputted into the unsymmetrical MZI switches GSW9-GSW16 is set to -20dB or less, to these, it is unnecessary in supply of offset power. In order to correspond to the supply pattern of such offset power, as shown in drawing, it has D/A converter 14 of an n-tuple, an adder 15, a current regulator circuit 11, and the analog switch 34 of nx16 configurations. In addition, according to the cross talk value required of the condition and the optical space switch of a cross talk, n is suitably determined in 1-16. Anyway, circuit magnitude can be substantially made small.

[0035] Thus, the optical space switch in which switching operation is possible is realizable with a necessary minimum configuration by using the driving gear shown in drawing 4.

[0036]

[Effect of the Invention] As explained above, in the optical space switch of this invention, ***** which stops a cross talk small is made by arranging an unsymmetrical MZI switch as a gate switch to each output port, and making off unsymmetrical MZI switches other than the output port of signal light. Moreover, to the thermo-optic effect optical switch which switches signal light, since supply of the offset power for reducing a cross talk becomes unnecessary, while being able to simplify a driving gear, power consumption can be reduced.

[0037] Moreover, since the laser trimming resistance for supplying offset power to a driving gear becomes unnecessary, the optical space switch excellent in fabrication effectiveness, versatility, and a power controllability can be constituted.

[Translation done.]

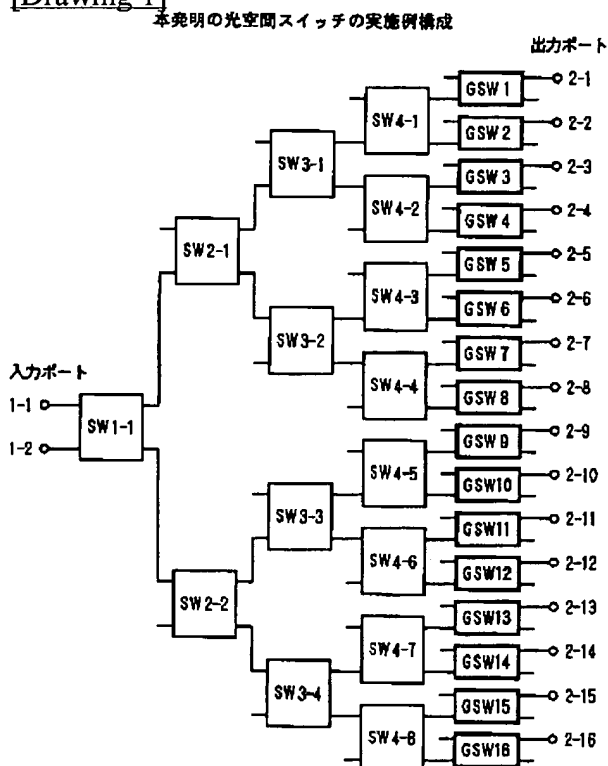
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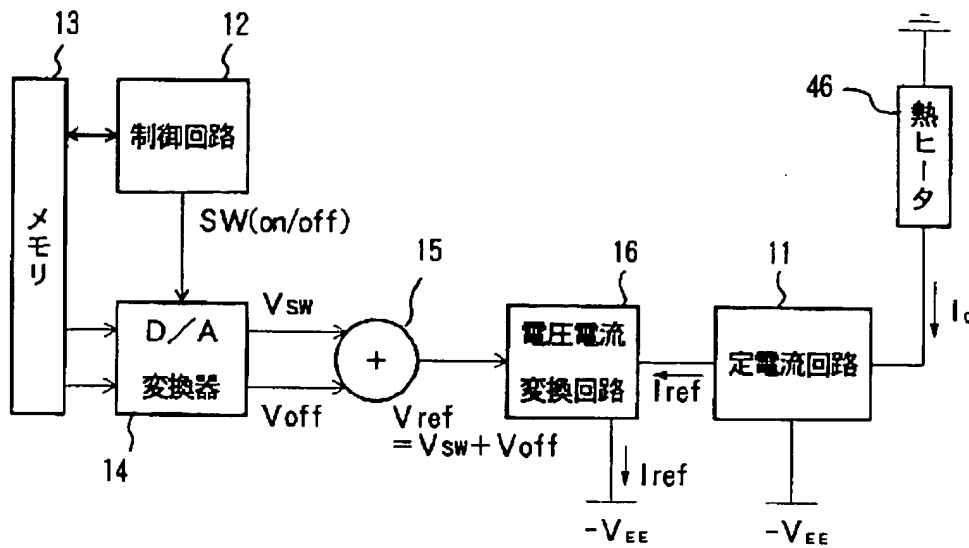
DRAWINGS

[Drawing 1]



[Drawing 2]

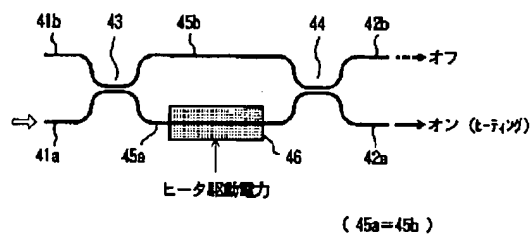
非対称MZ I スwitchの駆動装置の基本構成



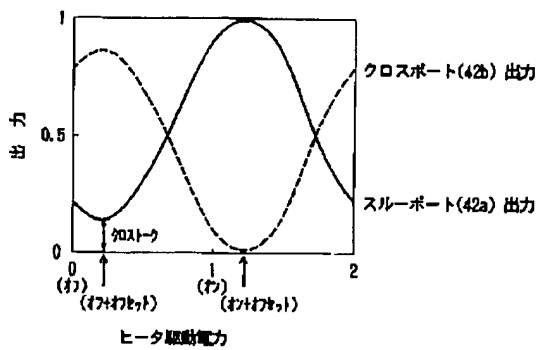
[Drawing 5]

対称MZ I スwitchの基本構成およびスイッチング特性

(a)

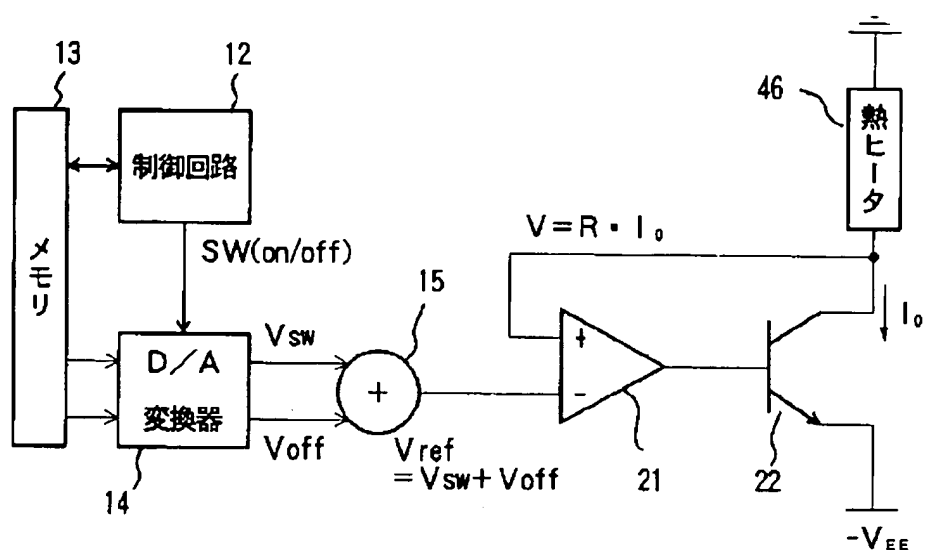


(b)



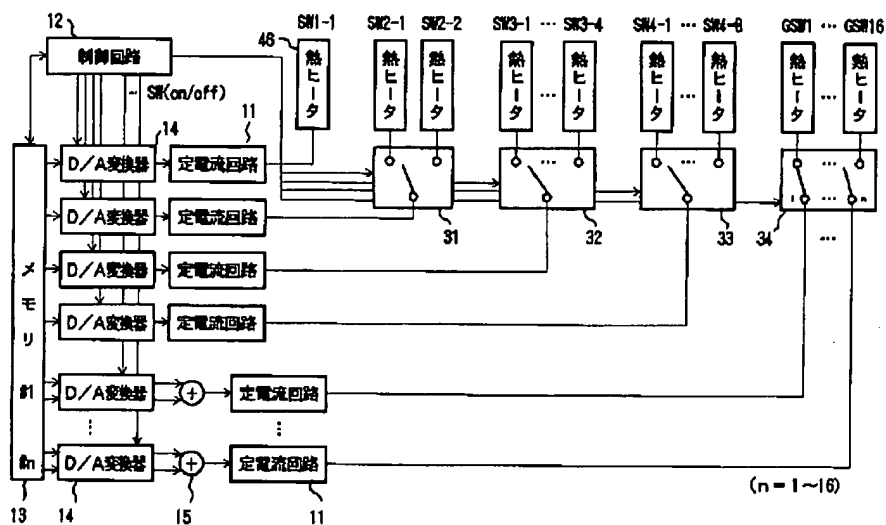
[Drawing 3]

非対称MZIスイッチの駆動装置の実施例構成



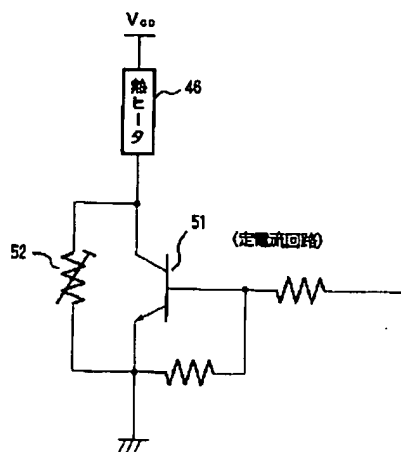
[Drawing 4]

図1の実施例の光空間スイッチに対応する駆動装置の構成例



[Drawing 7]

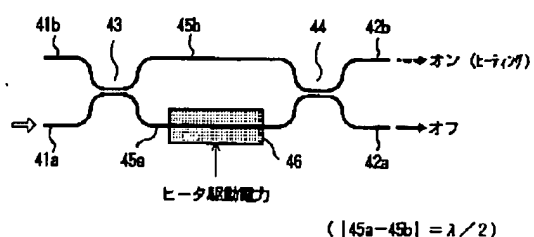
従来の熱光学効果光スイッチ駆動装置の構成



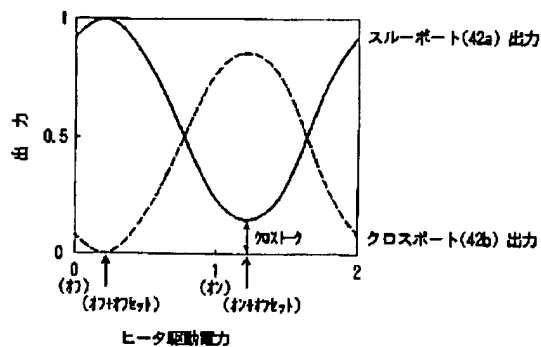
[Drawing 6]

非対称MZIスイッチの基本構成およびスイッチング特性

(a)



(b)



[Translation done.]